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TEN TOTAL ECLIPSES

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My undergraduate life was started in 1890 at Queen's University under the inspiring teaching of Professor Nathan F. Depuis in mathematics. Later astronomy was added in my junior year under "Old Billie" (Rev. James) Williamson as he was affectionately called by the students. He was a brother-in-law of Sir John A. MacDonald. He had started his teaching at Queen's in the year 1842, a member of the first faculty. As the university increased in size and the faculty grew in numbers, the subjects taught by "Old Billie" became fewer and fewer, until when I first knew him in the nineties he taught only astronomy. His home was but two blocks from my home and he got into the habit of ringing the front door bell to ask me to go with him to the little wooden observatory. Professor Dupuis had himself constructed the sidereal and the mean time clocks, but he was not entrusted with a key to the small observatory. In addition to the two clocks, the observatory (Douglas, 1958) consisted of a 6¾-inch Alvan Clark refractor and a transit instrument. I was taught to observe for time with the transit instrument and by the eye and ear method. The transit instrument was borrowed from the Royal Astronomical Society of London. In winter nights I had a chance to become accustomed to making observations in the cold for the observatory was inadequately heated by a stove, but the professor would try to keep warm by wrapping himself in two overcoats with a muffler round his neck and one around his waist.

When "Old Billie" died, the keys were in my possession and I was placed in charge of the observatory and made a tutor in physics. The next

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session I was made tutor in mathematics. But Professor Dupuis recommended that I should take graduate work at the Johns Hopkins University where the distinguished Canadian, Simon Newcomb, was in charge. When I reached Baltimore, I found that Newcomb had retired and had returned to the Naval Observatory. I thus came under the influence of Rowland, Ames, Jewell and Charles Lane Poor in celestial mechanics.

As a partial fulfillment of the degree of Ph.D. the subject adopted was "The Application of the Concave Grating to Stellar Work". With a small grating, tests were made in the observatory on the roof of the Physics Laboratory and as they proved that the method would give excellent spectra, a six-inch grating of short focus was ruled on Rowland's engine.

The following year I went to the Yerkes Observatory. When I reached Chicago, I went to pay my respects to Director George E. Hale at his home at the Kenwood Observatory. His father had recently died and he would not be in residence during the winter term at Yerkes.

That same afternoon, I took the 5:10 p.m. train to Williams Bay. Out of the kindness of his heart, Professor Barnard walked the 1½ miles from the observatory through a cold rain. He said later "The only person on the train was a small boy." I was met by a buggy and went to the home of the Superintendent of Grounds at the Y.M.C.A. camp at Lake Geneva, my home while at Yerkes. The following day at the observatory I met Barnard, while a few days later Burnham came up from Chicago for his usual two nights with the 40-inch refractor. Ritchie and Ellerman were both in residence, the former busy grinding the two-foot reflector, and the latter photographing stellar spectra and in the daytime using the spectroheliograph on the sun. Hale and Frost were not in residence until the summer.

The 6-inch concave grating in its wooden box was mounted on the 12-inch refractor which was used merely as a guiding mechanism. One memorable night, I worked for 13 hours (and Barnard was at the 40-inch) and the temperature where we worked was only −26°F. Then there were no electrically heated clothes, now so common for aviators. All one could do was to try to keep from freezing to death. But if Barnard could stand it, why shouldn't I, a mere youngster, as he had called me? That winter the ice on Lake Geneva froze to a thickness of 24 inches and was harvested in great ice houses and in the summer time was shipped by train for commercial purposes. In June I was appointed instructor in astronomy at Columbia University.

As a result of my work with gratings at the Johns Hopkins University, I was an invited member of many Naval Observatory eclipse expeditions. My first in May 1900 was south to Griffin, Georgia, where I worked with

my friend, L. E. Jewell. My second expedition took us nearly half way round the globe to Sumatra where totality was of long duration, nearly six minutes. The trip was a fascinating one. We assembled at San Francisco and then boarded an army transport, Barnard and I sharing a stateroom. We spent three days in Honolulu, the "Garden of the Pacific", and then west on to Manila, the trip from San Francisco to Manila taking 30 days at 10 knots. The Spanish ships of Dewey's "Battle of Manila Bay" were lying half submerged at Cavite. The expedition spent two weeks in Manila while the Navy was preparing a Spanish gun-boat to carry the expedition on the 2,200-mile trip out past Corregidor, then south along Palawan, then past Sarawak and Borneo, and then we crossed the equator where Father Neptune came aboard. Through the Straits of Sunda, we steamed close to the island of Krakatau and still further north to enter the harbour of Emmahaven to the city of Padang. The expedition was planned to settle in Solok, but as the weather was found to be cloudy, both day and night, it was decided to send me 25 miles away along the railroad to the terminus of the line at Sawah Lunto. I took with me a grating spectrograph and a camera. The superstitious natives were quite sure that at totality a dragon would come and swallow the sun. Although the skies were not perfectly clear I was able to secure photographs of the flash spectrum.

My third expedition was in 1905. Admiral Colby M. Chester was the Superintendent of the U.S. Naval Observatory. He had a special service squadron of three ships. I was on the flag ship, U.S.S. "Minneapolis", then the fastest ship in the world; it was capable, at foreed draught, to go at the phenomenal speed of 22 knots. The ship left New York on July 4th and we crossed the Atlantic and stopped for one day at the Azores. We reached Gibraltar at 7:00 o'clock in the morning. The British Mediterranean squadron in port consisted of eight battleships and an equal number of cruisers under the command of the ranking admiral of the world, Lord Charles Beresford. On entering port, it required 154 rounds of ammunition before Uncle Sam could say "How d'ye" to Johnny Bull and then could be saluted in return. In the afternoon we could have a cup of tea with the British officers while at night the British fleet was illuminated in our honour.

We spent two days in the port of Gibraltar and it was a splendid sight on the second morning to witness the British ships leave the harbour in perfect formation.

The "Minneapolis'" then went to Valencia where the members of the expedition saw a bull-fight in the largest ring then in Spain. The following day, two of us took train to Daroca, passing through Sagunto where

Hannibal and the Romans had a memorable battle in 238 B.C. Daroca was reached at 10:30 at night and with our indifferent Spanish we had to find a hotel, which the two of us occupied for six weeks, and the following morning at noon we made an official call on the *alcalde* in order to find a location where navy personnel could come ten days before the eclipse on August 30.

Padre Felix, the principal of the elementary College of Daroca, and the local apothecary both had an interest in photography. On account of this interest Padre Felix came to call on me in the late afternoons after work, and took me for a walk to explain the chief events connected with the interesting history of the city. Crowning the hill was a Roman fort of seven stories. There was an aquaduct that brought water into the city. The Moorish fortifications surrounding Daroca had been largely demolished. Much fighting had taken place close by during the Peninsular war and in the many uprisings that were always taking place in the Spanish kingdom.

One of the happiest moments in my life was occasioned by a knock on the door from Padre Felix at 2 a.m. I had just finished the development of the eclipse spectra. I could see that my plates showed exquisite definition and exact timing! It was early in the history of astrophysics. It was many long years before science could learn about the structure of the atom and ascertain the reasons why heights and pressures in the solar chromosphere could be the cause of "enhanced lines". This entailed many long years of concentrated work.

My fourth eclipse was observed in Baker, Oregon on June 8, 1918. A year before the eclipse, I had gone to New York to see my friend, Edward D. Adams, a pioneer in developing electric power at Niagara Falls. I invited him to go with me to see the eclipse. I told him that photographs of short exposure gave the inner corona in exquisite detail; longer exposures gave the outer corona but the inner corona was burnt out. I asked him if he could find an artist to paint the corona. About a week later he wrote and gave me the joyful information that he would take on my problem. As he was a close friend of George Eastman he wrote to the head of Kodak and asked him if the problem could not be accomplished by colour photography. Not being an expert on the photographic details Eastman turned the problem over to the head of the research laboratory, Dr. C. E. K. Mees, a friend to all astronomers, he in turn referred the matter to his friend, S. A. Mitchell. By diligent search, Mr. Adams found a distinguished portrait painter, Howard Russell Butler of Princeton. The description by Mr. Butler and a copy in colour of the original painting will be found in the first edition of "Eclipses of the Sun", 1923.

My fifth expedition for the Sept. 10, 1923 eclipse took me to San Diego so that I might take advantage of the "beautiful clear skies of Southern California". Although insurance was offered at very low rates, it didn't seem worth while to waste money on a near certainty. The Navy had a station nearby, and plans were made to photograph the edge of the moon's shadow as it moved across the ground. Mount Wilson had a superbly equipped station on Point Lome and I had a second station inland near the edge of the shadow cone. However, thin clouds covered the sky.

In spite of the ill luck with the California weather, the flash spectrum needed to be photographed, and my sixth expedition was to Wesleyan University Observatory, Middletown, Connecticut to observe the eclipse at nine o'clock on a winter's morning on January 24, 1925. This was my first winter eclipse and the temperature at the time was 6° below zero. We could taunt "beautiful sunny California" for we had clear skies but the definition was not of the superb character of the Spanish eclipse on account of the high altitude of the sun there and the splendid seeing.

The next eclipse path went over England and Norway but the total phase lasted only 38 seconds. But "nothing venture, nothing win". The eclipse took place on June 29, 1927. We took ship to Oslo, and then 125 miles farther north to Fagernes. On account of the high northern latitude it was a bit difficult to adjust apparatus for no stars were visible to assist us. When totality came it was pretty cloudy and no hole in the clouds came where our instruments were directed. Forty people representing ten nations were gathered together. It was a delightful experience even though without scientific results.

After the eclipse, with my family, I met the first man in Norway at the time, the great Arctic explorer, Fridtjof Nansen. Later, we had an overland trip to Bergen and then to the "land of the midnight sun" to the North Cape and returning to Bergen, we crossed the mountains to Stockholm before returning home.

My eighth expedition for the Oct. 22, 1930 eclipse, was again to the tropics and meant a voyage by the Matson Line to Honolulu and then on to Niuafo'ou or "Tin Can" Island at 15° south latitude in the South Pacific and nearly on the international date line. This was the only island in the Pacific where the eclipse was total. At Pago Pago, in American Samoa, I left the ship and took 115 cases of scientific instruments and supplies, 60 tons of stores and 11,000 feet of lumber. My wife went on to Suva, the capital of the Fiji Islands. U.S.S. "Tanager" was detailed to assist in the work to transport the astronomers and supplies 400 miles to Niuafo'ou. There two officers and a dozen sailors were left in order to assist in the erection of the 65-foot tower telescope, two Einstein cameras

and two concave grating spectrographs. Niuafo'ou was a most interesting volcanic island of the Tonga group with an interior lake 800 feet above sea level. It grew the largest coconuts in the Pacific. The year before the expedition there was a violent earthquake and a native village was covered by hot lava. The island lay in the path of the trade winds and there was no harbour and no boat could be kept in the water. Among the 1,100 villagers living in nine communities, there were but two white men, one a trader from one of the two trading companies on this island. The island belonged to the "Friendly" group which signifies that when a native wished to become your friend and you accept, the friendship was sealed by his giving you a present, and in turn you were expected to offer him your friendship which requires that you reciprocate by making a present to him. In anticipation of this custom we had gone before leaving home to the 10-cent stores and had provided ourselves with gorgeous jewelry. With these gifts and cigarettes, we were well provided with suitable presents. My native friend, son of the head man of one of the villages presented me with a cocofibre mat for the floor of my tent. The Tonga group of islands belongs to Great Britain and was administered by H.E. Sir Murchison Fletcher in Suva, Fiji Islands.

My wife was in Suva for a period of six weeks with letters of introduction to H.E., the governor of the islands in the Pacific Ocean, and also to an American who had been formerly consul in Serbia. His wife was a Rockefeller doctor whose duties carried her to the native villages where she cared for the health of the natives, particularly the little babies. The Tonga Islands were a widely scattered group with their own parliament and their own queen who was an inspiring personality at the coronation of Queen Elizabeth II.

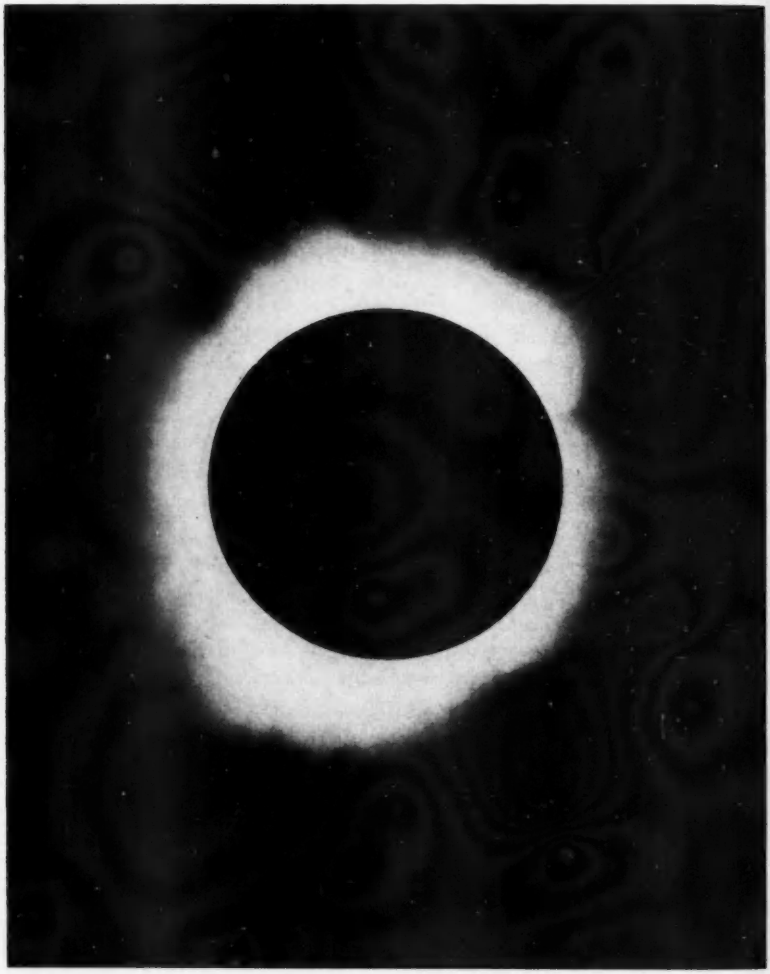
We had travelled a long distance by sea to Niuafo'ou, what was to be our luck with the weather? Totality was to come at 8:51 in the morning. When we awoke at six o'clock a fine rain was falling. First contact was observed through the clouds. But it soon began to clear, and a quarter of an hour before totality the clouds had all cleared away and a miracle had happened. A half-hour after totality, the clouds had gathered again and persisted for the balance of the day. We had been working under tremendous odds but the fates were with us. The development of the plates was a serious problem. There was no running water on the island and we stirred up fine lava dust when we took a step. Water and ice for the development had to be brought by the Navy. We were a thrilled group of astronomers when the photographic plates and eclipse films were developed and hung out to dry. I have never seen more beautiful detail than appeared on Merriott's photographs of the corona, and my own eclipse spectra with two concave gratings were in excellent definition.

The superb luck demanded a celebration! This was given by order of the queen. It consisted of a banquet laid on the floor of the school house consisting of native delicacies. The high-chief, Fotofeli, was first to be served, and then the food went down one side of the table and up on the other. The banquet was naturally served without knives and forks. Fingers had to be cleansed in basins of water starting with the honoured guests and then up the other side of the banquet laid on the floor. After the banquet was cleared away, we could dance with the native belles and try to keep from treading on their bare toes.

My ninth eclipse was the New England eclipse of August 31, 1932. My party was located 100 miles east of Montreal at Magog, Quebec. Here also were assembled an English party under Stratton of Cambridge, a Dutch party under Minnaert of Utrecht and a Canadian party from McGill University. Wide-spread clouds and clear spots appeared along the eclipse track. Unfortunately for the large party assembled at Magog, the hole in the clouds did not come where we were located. The Lick Observatory party, under Menzel, the Michigan party and others were successful—but it was not my good luck.

Early in 1937, I was invited by the National Geographic Society to organize a total eclipse expedition for the June 8 eclipse, memorable for the longest duration of totality in more than twelve hundred years (since the year 699). Two locations for the expedition were possible in its swing of 8,800 miles across the Pacific Ocean; on one of the islands of the Phoenix Group near the international date line and 3° south of the equator, and in Peru where totality occurred shortly before sunset. With the assistance of the U.S. Navy, the expedition was located at Canton Island 1,880 miles south and a little west of Honolulu. This is a coral atoll with no life on it except rats and hermit crabs, and you had to be careful that one of them did not crawl into bed with you. When we landed on the island we saw a placard in a conspicuous place nailed to one of the coconut trees which stated, "In 1936, this island was taken possession of in the name of His Majesty King Edward VIII". Nowadays, by contrast, this island is a very busy place with a large hotel, an important air station on the flight from California to New Zealand. The expedition was on the island only half the time that we were on Niuafo'ou or Tin Can Island in 1930, twelve degrees farther south. On Tin Can Island, our tents were in the shade of large coconut trees but on Canton Island there were only a half dozen trees too mangy to give shade. In the frantic rush we worked from sun-up to sun-down and during the twelve-hour day we had a double dose of the heat of the sun, from the direct rays with their blistering heat and again from the broken coral underfoot.

The activities of the expedition were kept in the public eye by frequent



The corona, 1937. Photograph by the U.S. Navy-National Geographic Society Expedition to Canton Island.

radio talks, about twenty in number, from the National Broadcasting Company. On May 26 the trim H.M.S. "Wellington" arrived bringing a party from New Zealand headed by my friend Michie who had been on Tin Can Island seven years earlier.

In spite of the short time available for selection of the best personnel and equipment we did our best. Direct photographs of the corona were taken by the Naval Observatory, by the Bureau of Standards or by Georgetown University. Richtmyer of Cornell University took care of determining the total light of the corona compared with that of the full moon and also of measuring the polarization of the light of the corona. For the first time at an eclipse polaroid filters were used. Dunham of Mount Wilson Observatory had superb equipment constructed especially for the eclipse. I had to be content again with borrowed equipment. I used three concave gratings and photographed with fixed plates.

During the hectic days of preparation the weather was very similar to that on Tin Can Island in 1930 with many clouds and little rain. The great question always present in our minds—what would it be like on eclipse morning about an hour and a half after sunrise. A half hour before sunrise I had to make a talk over the radio. It was then cloudy as it was at Niuafo'ou. I must confess I had to lie like a trooper when I gave my confident opinion that a miracle would again happen and brush the clouds away. It was clear before first contact and for more than two solid hours thereafter, only one isolated cloud covered the sun and nearly half an hour after the total phase of 3 minutes and 33 seconds had passed into history.

The details of the eclipse have been published by the *National Geographic Magazine* for September 1937 and in the first number of *The Solar Eclipse Series* published in 1939.

One of the most pleasant parts of the whole expedition for me came a little before noon, a few hours after the thrilling excitement of the eclipse was all over. I engaged in a two-way broadcast with my friend of many long years, the distinguished astrophysicist Alfred Fowler. Fowler in 1893 had secured the first photograph of the flash spectrum, and the flash spectrum had been my specialty in all my ten total eclipses. I was on a tiny speck of an island in the middle of the Pacific Ocean and I was separated from him in London almost as distant as possible, half way round the globe.

The author of this article has been most fortunate in having had rare good luck with the weather for he has actually seen the corona in all but two of his ten expeditions. He has never had rain nor completely overcast skies at the time of totality. He has had a life of much travel by sea: 21 times across the Atlantic Ocean, five times across the Pacific, from North Cape at 72° N. latitude to Melbourne, Australia. He has made a round-the-world trip and participated in observations of ten total eclipses of the sun. The corona that exhibited the most spectacular beauty was not

the first eclipse witnessed in 1900 of minimum type, but the eclipse of 1918, of pronounced colour, the prominences being large and brilliant. The contrast in the structure of the corona has left a never-to-be-forgotten image of beauty. This was the subject of the first and undoubtedly the finest of Howard Russel Butler's paintings. The original painting was given by the family of Edward D. Adams and now finds an honoured position at the University of Virginia.

In closing this article I would like to quote a statement from a distinguished solar investigator (Plaskett, 1937) "On the purely technical side, eclipse observations may very properly be regarded as the most difficult branch of observational astronomy. The design of delicate apparatus which is yet portable, the visualization of and the preparation for emergencies which may occur at any eclipse site, remote from the necessities ordinarily so regarded, of scientific research, the erection and adjustment of the apparatus on such a site, and finally the crucial three or four minutes when every factor, meteorological as well as psychological, is heavily weighted against the observer, all demand the utmost of skill. Even when the occasional photograph or spectrum has been obtained, the observer is still not finished, for he has now to measure and interpret photographs and spectra almost necessarily obtained under conditions far from ideal."

As a result of a prodigious amount of labour spent over many long years, 3,500 lines in the chromosphere have been studied (Mitchell, 1933) between the wave-lengths 3066 A. and 8863 A. together with their heights and intensities.

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A PROBABLE NATURAL SATELLITE: THE METEOR PROCESSION OF FEBRUARY 9, 1913

By John A. O'Keefe
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The great meteoric procession of February 9, 1913 (Chant, 1913) was unique in several respects:

(*a*) It is the only well-attested case of a shower lasting longer than a few seconds, and less than half an hour. Very brief showers may result from the break-up of a single body in the upper atmosphere; prolonged showers result when the earth crosses a meteor steam. A shower of intermediate length implies the arrival in lower atmosphere of a group of objects.

(*b*) It is one of the very few cases of a shower in which the objects followed in one another's path so closely that the width of the stream on the sky was only a few degrees.

(*c*) It was observed over a longer path than any other single fireball or cluster of fireballs.

The observations were put together by C. A. Chant (1913). Later discoveries of observations at sea were made by W. F. Denning (1915, 1916) and W. H. Pickering (1923b). A most important compilation of observations in the United States was made by A. D. Mebane (1956), based upon reports in local papers and from witnesses.

The orbit was discussed by the Rev. M. A. Davidson (1913a, 1913b) and by G. J. Burns (1913a, 1913b) and W. H. Pickering (1922, 1923, a, b, c). All of these writers were led to the conclusion that the orbit of the bodies was essentially satellitic.

Much later, C. C. Wylie (1939) attacked this explanation. He gave four reasons for thinking that it was a normal meteor shower:

(*a*) The rising of a shadow-casting fireball from behind objects on the horizon would be an impressive spectacle. Yet no witness refers to seeing this.

(*b*) Similar considerations apply to the setting of a great fireball.

(*c*) The shooting stars of the 1913 group must have been at a different height than the detonating meteor. (This is particularly applicable to some work by Pickering on the determination of heights from sound data.)

(*d*) A detonating meteor cannot be higher than about 25 miles. At this height, a body will travel only 7 to 8 miles against the resistance of the air.

Wylie sought to explain all of the observations in terms of a radiant which, as seen from a point at longitude 80° W. and latitude 43° N., would have the following characteristics:

Azimuth of the apparent radiant	331° (from N. through E.)
Altitude of the apparent radiant	+20°
R.A. of the apparent radiant	327° 15′
Declination of the apparent radiant	56° 40′
R.A. of the corrected radiant	315° 15′
Declination of the corrected radiant	46° 16′
Apparent velocity	10.1 mi./sec.
Geocentric velocity	7.33 mi./sec.

Wylie discounted the Canadian reports which indicated that the flight appeared nearly level. He remarked that he had satisfied himself by graphical computations that this apparent radiant, and the orbit computed from it, would account for the observations made by the ships at sea.

To check Wylie's computations, five points have been chosen, at roughly equal intervals, along the path. The first point, at Regina, in Saskatchewan, is to be compared with two observations (Chant, 1913); the second, at Toronto, with over a hundred observations in Ontario (Chant, 1913); the third, in Bermuda, with two observations (Chant, 1913); the fourth, at the position of the ship "Bellusia", with the observations of the captain and first mate of that ship (Denning, 1915a) and the fifth, at the position of the "Newlands", with the observations of the first mate of the ship (Denning, 1916). Since the time was given only very roughly by the "Bellusia", two computations have been made, for times half an hour apart, to illustrate the fact that the conclusions do not depend to any important degree on the adopted time.

The table summarizes the computation of altitude and azimuth of the apparent radiant as seen at these five points as calculated from five different orbital assumptions. The first three columns are self-explanatory; the fourth gives the U.T. from Greenwich midnight, as it would be computed now, although at that time use was made of Greenwich Mean Time, from noon.

The fifth and sixth columns give the altitude and azimuth of the apparent radiant at the adopted points, calculated from the Wylie right

Selected Observation Points

Name	Lat.	Long.	U.T.
(1)	(2)	(3)	(4)
Regina	+50° 27′	104° 36′ W.	2:00
Toronto	+43 00	80 00	2:06.5
Bermuda	+32 15	64 50	2:10
"Bellusia" (1)	+16 39	50 15	1:51
"Bellusia" (2)	+16 39	50 15	2:21
"Newlands"	+16 39	50 15	2:21

Name	Wylie Radiant					
	u = 11.26 km./sec.		u = 0		u = 3 km./sec.	
	Alt.	Az.	Alt.	Az.	Alt.	Az.
	(5)	(6)	(7)	(8)	(9)	(10)
	°	°	°	°	°	°
Regina	+33.9	314.6	+28.7	304.3	+29.9	309.0
Toronto	+20.2	331.0	+20.0	331.0	+20.0	331.0
Bermuda	+ 8.2	341.9	+13.0	354.9	+11.7	345.8
"Bellusia" (1)	−5.3	353.2	+ 9.0	57.0	+ 2.8	10.1
"Bellusia" (2)	−6.2	351.8	+ 6.3	36.9	2.6	357.3
"Newlands"	−20.5	7.1	+17.1	106.3	− 1.0	57.4

Name	Best Meteoric Orbit		Circular Orbit	
	Alt.	Az.	Alt.	Az.
	(11)	(12)	(13)	(14)
	°	°	°	°
Regina	+42.3	281.9	0	283.2
Toronto	+32.6	301.2	0	303.3
Bermuda	+24.4	310.2	0	315.0
"Bellusia" (1)	+13.3	371.1	0	322.2
"Bellusia" (2)	+16.0	306.4	0	322.2
"Newlands"	0.0	Indet.	0	324.4

Statements of Witnesses:

Regina area: "Did not appear to be on a downward course, but on more of a straight line from east to west" (Mortlach); "Directly overhead from east to west" (Pense).

Toronto: North-west to south-east; level flight.

Bermuda: North-west to south-south-east. "Horizontally with a slight downward tendency as a whole."

"Bellusia": Started at north and went by way of east to south-east.

"Newlands": First seen in west; went to south.

ascension and declination of the corrected radiant by the formulas of Bauschinger (1906), as follows:

$$w \sin (z - \tfrac{1}{2}\zeta) = u \sin \tfrac{1}{2}\zeta,$$

where w is the velocity near the observer; u is the so-called geocentric velocity, i.e. the velocity which the body would have had if the earth's attraction had not been acting; z is the zenith distance of the apparent radiant; ζ is the zenith distance of the corrected radiant.

This equation is incorrectly given by Olivier (1925). The zenith distance was checked by the formula

$$\tan \tfrac{1}{2}\phi = \frac{w - u}{w + u} \tan \tfrac{1}{2} z,$$

where ϕ is the zenith attraction, $\zeta - z$.

The calculations show that the orbit proposed by Wylie cannot account for the observations, since the altitudes found for the "Bellusia" and "Newlands" are negative. In theory, small negative altitudes are possible; but a check of 750 fireballs in the catalogues of Denning (1897, 1912, 1915b) shows only two whose final heights were greater than their initial heights; and in these cases, the negative altitude angles were less than 1°. It follows that we must discard either the proposed orbit or the testimony of the ships. Both accounts are by the ships' officers; the "Bellusia" in particular filed a sworn statement signed by the captain and first mate (Denning, 1915). We conclude that the Wylie orbit must be discarded.

To see whether the failure of this orbit could be remedied by a change of the velocity, a second orbit was worked out, as shown in columns 7 and 8. For this orbit, the same altitude and azimuth were assumed at Toronto as for the first orbit; but the geocentric velocity u was taken equal to zero; i.e., the orbit is parabolic around the earth.

It is found that all altitudes are now positive; the difficulty is with the azimuth. At the "Bellusia" the calculated azimuth differs about 90°, at the "Newlands" about 135° from those reported. Since the witnesses presumably had the ship's compass before them, and were in any case aware of the ship's course, these errors in azimuth are too large to be accepted.

We next seek a third orbit intermediate between the first and second orbits, with the objective of reducing the azimuth discrepancies to the minimum consistent with positive or only slightly negative altitudes of the radiant. The results are shown in columns 9 and 10. The azimuth at the

"Newlands" is still 90° away from that observed. The velocity used in this orbit ($u = 3$ km./sec.) represents the best that can be done with the apparent radiant accepted by Wylie for the Toronto area. If the velocity is increased, we get negative altitudes; and if it is decreased the azimuths become even worse.

Abandoning the Wylie apparent radiant at Toronto, therefore, we now ask what radiant and velocity will most nearly satisfy the observations. In columns 11 and 12 are shown the results of taking the geocentric velocity zero, and the corrected radiant at the nadir point of the "Newlands". We see that all of the azimuths are reasonable. That at the "Newlands" comes out indeterminate because the "Newlands" is precisely antipodal to the corrected radiant; but this is not in conflict with the observed azimuth. None of the calculated altitudes comes out negative.

This orbit also fails to satisfy the observations. At the Mortlach station, in the Regina area, the observer reported that the group motion was "not downward"; but the calculated motion in column 11 is downward at an angle of 42°. In the Toronto area, where there are over a hundred reports, the evidence is strongly in favour of flight very nearly parallel to the surface of the earth, yet the calculations here call for a radiant at an altitude of 32°. It is significant that the witnesses had much more time to examine the phenomenon than they usually do in the case of fireballs. Not only was the flight slower than usual, but it was repeated several times with different groups of meteors over a period of minutes.

As a check on this line of reasoning, compare the observations of random fireballs on the same night, also collected by Chant (1913) and published with those of the procession. It will be noted that most of the accounts speak of a downward motion.

It is concluded that this fourth orbit fails to satisfy the observations by amounts up to 40°. This orbit is, however, the best normal meteoric orbit that can be found. To show this, consider the orbit as specified by the apparent altitude, azimuth, and velocity as observed at Toronto. Evidently the azimuth cannot be improved; a change in this will affect all azimuths along the path. Since these are satisfactory, the change will not help; and, in fact, the azimuths at the southern end of the path are extremely sensitive to the exact value of the azimuth assumed at Toronto. If we decrease the altitude at Toronto, we will decrease it along the line, and hence get negative altitudes at the "Newlands". If we increase the altitudes at Toronto, we make the discrepancies between theory and observation worse. If we increase the apparent velocity, we get negative altitudes at the "Newlands"; if we decrease it we have a satellitic orbit.

It follows that no normal meteoric orbit will satisfy the observations. The fundamental difficulty is that the observations indicate an orbit which follows the curvature of the earth over an arc of almost 90°. This is only possible if the orbit is nearly circular.

In addition to the mathematical objections to the Wylie orbit, there are physical objections. Each observer saw a narrow train of objects crossing the sky. The Wylie theory requires that the trains seen at different points be actually different trains, so that the whole shower would have to consist of a set of parallel filaments. This raises the question why the observers in one place did not see the filaments observed in other places, as well as their own filament.

In the papers of Chant, Denning, Pickering, and Mebane the path is covered from Saskatchewan to Brazil, without any serious gaps. Hence the filaments observed at various points should have blended into a sheet covering the whole sky; and this was definitely not observed.

Before adopting a satellitic orbit, let us review Wylie's objections, as given above. The first two refer to the failure of the witnesses to mention the rising or the setting of these brilliant objects behind objects on the horizon. In reply, we note that the Russian satellites were not often seen to rise or set; they normally appeared from and disappeared into the haze along the horizon. The third is valid, but does not affect the present discussion, since the arguments have not depended in any way on arguments about heights. Furthermore, this paper has been written with the idea in mind that the objects seen at one station may not have been the same as those seen at another. They may have belonged to a group of which only the lowest members were incandescent at any one time.

The fourth point is definitely incorrect. Mebane traced the detonations over a distance of 150 miles from the end point assigned by Wylie. It is quite possible that the individual detonating bodies did not go the full distance; but in this case there must have been a cluster of detonating bodies as well as a cluster of smaller objects, rather than only a single bolide, as postulated by Wylie.

We conclude that the meteors of the display of February 9, 1913, were travelling in a satellitic orbit around the earth. The elements of the orbit were approximately:

Period	90 minutes
Inclination	51°.6
Eccentricity	0
Terrestrial longitude of descending node	33° 20′ W.

Time of passage of descending node: 2:20, U.T., February 10, 1913.

Altitudes and azimuths of the apparent radiant calculated from this orbit are presented in columns 13 and 14; it is seen that they agree with the observations.

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ECLIPSE CHASING ABOVE THE CLOUDS*

By J. E. Kennedy†
National Secretary, R.A.S.C.

In January 1954, Dr. J. F. Heard delivered his Presidential address to the Annual Meeting of this Society on "The Solar Eclipse of June 30, 1954, in Northern Canada". This address, published in the March-April issue of the Journal of that year, includes a complete account of the planned scientific effort of astronomers from the Dominion Observatory, the Dominion Astrophysical Observatory and the David Dunlap Observatory.

The Journals for September-October and November-December of 1954 contain additional eclipse notes. In the former, a brief description is given of the set-up at Mattice where the group from the David Dunlap Observatory had planned to observe; in the latter are brief notes telling of preparations made by the astronomers from the Dominion Astrophysical Observatory and the Dominion Observatory.

Professor Stratton (an Honorary Member of this Society) contributed an article to this November-December Journal under the title "A Total Solar Eclipse Seen From Above a Bank of Clouds". In his opening sentence, he stated that "The writer has had considerable experience with eclipse observations from below banks of clouds". This may well be the comment of many astronomers who have encountered similar misfortunes. The unfavourable weather conditions which settled uniformly across Northern Ontario on the morning of June 30, 1954, brought disappointment to Dr. Locke's party at Smokey Falls, Dr. Wright's group at Hansen and likewise at Mattice to Dr. Heard, Dr. Oke and Miss Northcott. While the airborne expedition from the Dominion Observatory achieved some success, this seemed quite secondary when we heard that the efforts of our close associates on these various ground parties had been completely washed out by the weather.

The airborne expedition was not mentioned in Dr. Heard's Presidential address as plans for this part of the Canadian effort were not completed until later. It was mid-April before the R.C.A.F. could guarantee the availability of an aircraft suitable for "Operation Eclipse". The planning was somewhat hurried; the co-operation required of personnel from the Dominion Observatory, the National Research Council

*An address delivered to the Toronto Centre of the Royal Astronomical Society of Canada on February 18, 1958.

†Defence Research Medical Laboratories.

and the Royal Canadian Air Force to make this combined operation a success was an achievement in itself. G/C Kenneth Maclure, co-ordinator of the operation for the R.C.A.F., deserves great credit; his sound training in physics made him very understanding of the problems of satisfactorily mounting apparatus on board an aircraft. Dr. Peter M. Millman headed the scientific party, assisted by Dr. A. E. Douglas and other scientists from N.R.C., in addition to scientists from the R.C.A.F. and the Dominion Observatory.

Solar eclipses are not in a sense unusual occurrences; two should take place somewhere on the earth each year and perhaps as many as five. On the other hand, if only those eclipses are considered which cross a selected portion of the earth's land surface, for example Canada, then solar eclipses are rare. A plot of the paths of total solar eclipses which have crossed this region in the past 450 years shows a total number of 28. Before the year 2025, six more will occur in Canada. Toronto was in the path of a total solar eclipse in 1806 and again in 1925; a third has been promised for the year 2144.

It is thus apparent, taking into account the small number of eclipses and the short duration of each eclipse, that the number of minutes of observing time at totality which an astronomer can expect in a normal lifetime averages ten unless he chooses to chase eclipses as an occupation. The opportunity for any one individual to gather much data from the totally eclipsed sun is quite restricted. Whenever a path of totality crosses a large accessible land area, a concentration of scientific effort is normally put forward to obtain as much information as possible during these few precious minutes.

The path of totality on June 30, 1954, started in Minneapolis, coincident with meetings of the American Physical Society, and the Society took full credit for arranging this event. It then swept across Northern Ontario where accessible but rugged observation sites were selected for the parties from the three major Canadian observatories. After crossing Northern Quebec and the North Atlantic, it swept across Norway and Sweden where a large gathering of scientists was present at an international congress. The scientists brought along their equipment to the meetings as a means of covering both events. Finally, after crossing the U.S.S.R., totality ended in Pakistan.

There are certain essential differences in planning the operations of a ground party and those of an airborne expedition for a total solar eclipse. The airborne group does not have to decide on a base for operations until the day prior to the eclipse, provided the apparatus is sufficiently flexible to allow for alterations in altitude and azimuth of

the sun as these change with the position at which the path of totality is crossed. A ground party has selected its location many months in advance and has been on the site a month prior to the date of the eclipse. The members of the ground party must be prepared to withstand the hardships of living in the wilds. (Kodachrome slides supplied by Dr. Locke were shown illustrating the rugged country with a wilderness retreat, comfortable to an unexpected degree).

The selection of an aircraft is not too difficult, usually one has to be content with whatever type is available. In our case, the R.C.A.F. provided a North Star–the converted "Ice-Wagon". The carrying capacity permitted considerable flexibility in the number of personnel and the amount of equipment on board. The choice of equipment is difficult for either airborne or ground parties. For example–how large a spectrograph, coelostat and associated controls can be transported into a remote area? What is the maximum that can be operated satisfactorily in an aircraft? The Dominion Observatory ground party, under the direction of Dr. Locke, made the horizontal solar spectrograph from Ottawa as functional in the wilds of Northern Ontario as if it were at its home location. The time required to carry out the installation on the field–about three weeks, time to dismantle it–about three hours. The party from the David Dunlap Observatory had a complete installation of equipment at Mattice and the group from the Dominion Astrophysical Observatory, a commendable assembly of instruments at Hansen.

Two quartz spectrographs were carried in our aircraft, the forward one was a medium Hilger with a lens of 60 cm. focal length, aperture 5 cm. The other at the aft position was a smaller and faster Hilger with a lens of 21 cm. focal length, aperture 5 cm. These instruments were mounted on tables designed by N.R.C., fitted with anti-vibration tops, which had been tested on an earlier airborne expedition to photograph auroral spectra. When the vibrations of a North Star aircraft are considered, the tables performed their intended function with a high degree of efficiency.

The assignments for the airborne expedition increased in number as June 30 approached. In the final stage we were expected to:

(*a*) photograph the "flash" spectrum as well as the "coronal" spectrum. Two men were required at each spectrograph, one for image guiding, the other for operation.

(*b*) search for a day-time display of aurora as we would be operating in latitudes where this might appear. Following dark adaptation, this was carried out by naked eye observation and with the aid of carefully selected filters to give maximum contrast in visibility (MacLulich, Stevenson and members of the ground crew).

(*c*) observe solar prominences visible at the time of totality and prepare a coded radio message on their location for transmission to Sweden to arrive there before the total phase of the eclipse (Miss Miriam S. Burland, G/C Maclure and radio operator F/O Rosenthal).
(*d*) obtain direct photographs of the eclipsed sun for inclusion in the R.C.A.F. documentary film and the C.B.C. Television news coverage (F/O Jones, Paul Pequegnat).

The "Ice-Wagon" was in the process of being stripped of N.R.C. deicing equipment, patched up and made serviceable as we moved aboard. The installation of tables, quartz windows in the hatches, temporary power outlets for the instruments, camera support stands and other necessities were not individually lengthy operations but checks and tests were made on each of these installations. The elevation of the sun at the position where the path of totality is crossed is a critical control item in adjusting guiding mirrors and spectrographs. If the path were crossed at Kapuskasing (not far from the Dominion Observatory ground party site) the elevation would be quite different from that at some place over the North Atlantic. Some two or three weeks before the eclipse, ground tests were made at Ottawa although the latitude there differed considerably from that at either proposed eclipse path crossings.

For ground tests at Rockcliffe—the home base of the aircraft—the elevation of the sun at 6:00 a.m. and at 7:15 p.m. daylight saving time, corresponded with its elevation for the Kapuskasing crossing. About one hour later in the morning and one hour earlier in the evening the elevations of the sun corresponded with a possible North Atlantic crossing. Our days frequently started at 4:30 a.m. with arrival at the airport by 5:30 a.m. The mule was hitched to the aircraft and we were in motion by 6:00 a.m. In the evening, after a last check at 7:15 p.m., alterations and additions to the equipment sometimes kept us busy until 11:30 p.m. The schedule was repeated the following day if the sun chose to shine at these most pleasant hours.

After a week of this ground trial procedure, a short air trial was taken from the Rockcliffe airport in the latter part of an afternoon. A number of defects showed up as a result of this and were corrected before departing on full-scale rehearsal flights on June 22 and 23, one week before the deadline of June 30. An early morning take-off from the Rockcliffe station was followed by a flight across Northern Ontario on June 22; after simulated orbiting above Kapuskasing, the path of totality was crossed and the rehearsal ended as we approached Rupert House on James Bay. Following a direct flight across Northern Quebec, we landed at Goose Bay shortly after noon where the rest of the day was spent. On June 23, breakfast was enjoyed at 3:00 a.m., we were airborne by 4:30 and the

rehearsal for a possible North Atlantic crossing of the path of totality was flown. Immediately after the rehearsal, we returned to Ottawa via Seven Islands, Quebec and Three Rivers, without touching down at Goose Bay; weather conditions had closed in the airport shortly after our take-off.

The tests were most satisfactory! Not a single piece of control equipment on our spectrograph was operating on our return to the home base. Only the most conscientious efforts on the part of the instrument makers at the Dominion Observatory as well as the assistance of technicians both at the D.O. and N.R.C. made it possible to implement the repairs and alterations required before the take-off on the final flight of June 30. On our last afternoon in Ottawa, work had been completed permitting us to attend a final briefing and giving us the impression that we were well ahead of schedule!

The weather forecasts on June 28 indicated that conditions would be much better for operations from Goose Bay than for a crossing of the path in Northern Ontario. On June 29, a rather leisurely flight from Rockcliffe to Goose Bay enabled us to make checks on equipment along the route. An opportunity to view one of the most beautiful and spectacular sights of this northern country was made possible as we circled above Grand Falls on the Hamilton River, a source of great power which will probably be harnessed within a few years.

The Meteorological Office at Goose Bay predicted that high clouds would be encountered on June 30 but not nearly as high as were found. At the normal operating ceiling of the North Star, 20,000 feet, there were no openings visible. At 24,000 feet some improvement appeared and at 26,500 feet it looked as though we might be free from the overcast. As we prepared for the final run, the pilot stated that he would attempt to get another 1,000 feet altitude out of the "Wagon" so up we went. This gain in elevation was quite valuable when we hit the path of totality at 27,500 feet and in the clear.

Film calibrations were done a short time before the scheduled totality. As the image of the sun's crescent approached the vanishing point, cycling of the controls on the forward spectrograph was started. This permitted spectrograms of the light from the crescent to be taken at intervals of 1½ seconds, the exposure time for each being ¾ of a second. At second contact, the "flash" spectrum of the chromosphere appeared and the record obtained of it is given in figure 1. The spectrum of the corona, taken during totality on the spectrograph near the back of the aircraft, is given in figure 2.

The search for a day-time display of aurora gave a negative result; no

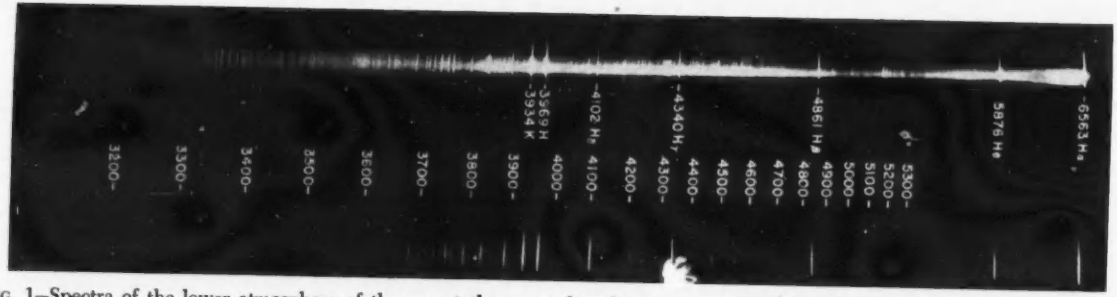

FIG. 1—Spectra of the lower atmosphere of the sun at the start of totality in the solar eclipse of June 30, 1954. The top spectrum was exposed before the disk of the sun had been completely covered; the bottom spectrum was taken 1½ seconds later, showing mainly bright lines from the sun's atmosphere. The wave-length scale is given on the print. (Reproduced with the permission of the Dominion Observatory, Ottawa.)

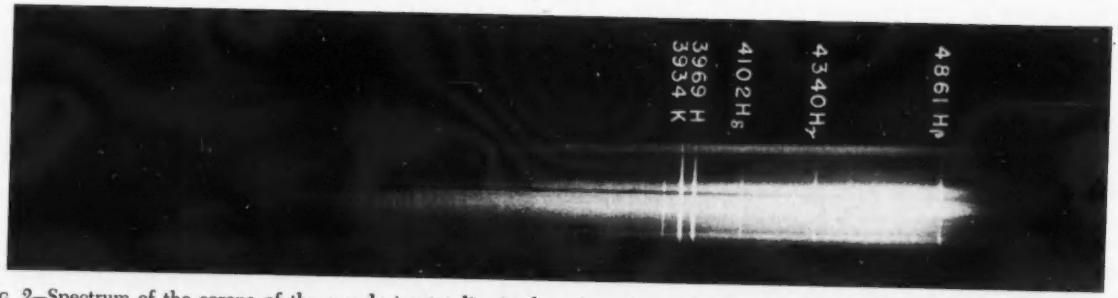

FIG. 2—Spectrum of the corona of the sun during totality in the solar eclipse of June 30, 1954. The wave-length scale is given on the print. (Reproduced with the permission of the Dominion Observatory, Ottawa.)

traces were spotted by any of the observers. The preparation of a coded message on the location of the solar prominences at totality went ahead without incident; while this message travelled by radio from the North Atlantic back to Kapuskasing before starting off to Sweden, it arrived there before totality reached that point on the earth's surface. The C.B.C. and R.C.A.F. photographers aboard the aircraft enjoyed reasonable success with their efforts in photographing directly the eclipsed sun.

Quite recently, reports have been released on experiments conducted in the U.S.A. where solar studies were successfully undertaken from a height of 80,000 feet. The R.A.S.C. is proud that one of its gold medallists, Donald Morton, was a member of this expedition. Few astronomers have been able to practise solar astronomy at these desirable altitudes but it is easy to see how an entirely new approach to eclipse studies will soon be practical. The spectra photographed in June 1954 were obtained largely because we were fortunate enough to be above a considerable layer of the earth's cloud-filled atmosphere which causes observational difficulties as well as producing a great deal of absorption in some spectral regions. Studies of the eclipsed sun had been made from the air before—both Dr. Heard and Dr. Millman had obtained creditable results on the 1945 eclipse in Northern Canada while they were members of the R.C.A.F. The airborne expedition of 1954 gave a better assessment as to the size of instruments which can be utilized in these studies in modern aircraft.

In the course of preparation for this expedition, some very memorable incidents took place from which a great deal of enjoyment was derived. It would be quite wrong to create the impression that it was all "hard work and no play". The issuing of safety equipment—as we were flying in a military aircraft—brought forward the suggestion that if there was any dissatisfaction with the operation of the parachute, please return it in person and another would be supplied. The inclusion of snowshoes in the aircraft among our survival equipment was to us somewhat amusing at first but later less so as we gazed down on the snow-covered ridges of Northern Quebec and Labrador on June 30. The memorable game of bridge at 8,000 feet during our flight to Goose Bay where all bidding had to be done by signs as it was impossible to be heard above the noise and vibration of the aircraft—these events served to break the ever-increasing tension and give the personnel some moments of relaxation.

Numerous questions have been asked concerning the most dangerous part of this whole operation. In retrospect, the greatest hazard to which any of the party were subjected was the danger of a fall on climbing the ladder to enter the aircraft, sometimes with heavy pieces of equipment

in hand. The explanation of this has been given in the remark of one character about to enter a North Star from a landing platform—"Look how high up we are already!"

In closing, may I quote again from the JOURNAL: "It is nothing short of thrilling to see the sun totally eclipsed, the black disk of the moon ringed with the rosy light of the chromosphere, studded perhaps by the Baily's Beads where sunlight still peeks through lunar valleys and the whole surrounded by the glorious pearly glow of the corona with pale streamers reaching out to distances of several solar diameters. No one who has seen this spectacle denies that it is worth waiting a lifetime to see—and not many people see it in their lifetime".

One small confession should be made—I have yet to see a total solar eclipse! I am hoping to be around in 1963 and perhaps free of the encumbrance of operating a spectrograph on board an aircraft at a high altitude.

(The documentary film "Operation Eclipse" was shown at the conclusion of this address.)

ASTRONOMERS VISIT FOUR U.S.S.R. OBSERVATORIES

By A. Vibert Douglas
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After the final meeting of the General Assembly of the International Astronomical Union in Moscow on August 20, 1958, various members, who did not have to leave the U.S.S.R. immediately, availed themselves of the opportunity to see something of the south central or of the south western regions of the Soviet Union. I selected the tour which kept me longest inside the country, the 9-day trip to Crimea, the Georgian S.S.R. and the Armenian S.S.R., in the course of which four observatories would be visited and perhaps—with the luck of the weather gods—Mt. Elbrus, highest mountain of Europe might be glimpsed.

I found myself the only Britisher in a group of 18 astronomers. We represented six nationalities: a few from France, Belgium, Sweden, Germany and the majority from the U.S.A. of whom one had been born in Bulgaria, one in Bessarabia, one in Germany, one in Scandinavia and one in Great Britain—enough variety to make an interesting party. The man of senior position in our group was Dr. Minkowski of Mount Wilson and Palomar.

Leaving Moscow late on the evening of August 21 we flew south over the great grain growing collective farms of the Ukraine, and put down at the large city of Kharkov in the darkness of night and in pours of rain. After a three hour delay we continued southward. The dawn light showed vast fields and far spaced villages. Later in the morning we crossed the blue waters of the Gulf of Azov near the isthmus joining the Crimea to the mainland. We saw the long railway bridge and the large industrial city of Dzhankoi, skirted the low infertile eastern coast, then inland over rising land toward the mountains of the beautiful south coast region. Landing at Simferopol in a blaze of subtropical sunshine, we were transferred to a bus which rattled us over tortuous roads and up into the mountains with fine grey escarpments, many evergreen trees and also poplars, acacias, many kinds of nut trees, sycamores and rowans in abundance. About 10:30 a.m. we drew up at a mountain restaurant high above a beautiful rocky coastline. Here we had breakfast before driving for another hour and a half through mountain roads and down the hairpin bends to the beautiful harbour front of Yalta. This is a lovely little city spreading in terraces far up onto the hillsides, its esplanades lined with palms and flowering shrubs. A long grey stone mole and lighthouse guard

the harbour where the passenger ships and the smaller tramp ships of the Mediterranean and Black Seas lie at anchor or at the wharves. The famous white marble palace of the last Czar lies in beautiful grounds on a high rocky promontory overlooking the blue waters of the sea a few miles south of Yalta. It is now a sanatorium for non-chronic cases of tuberculosis. To get admission to it or similar places we were told by our interpreter that it was necessary to get not only a medical certificate of need but a letter of recommendation from the Trade Union official.

From Yalta we visited two fine research institutions, the Astrophysical Observatory of the Crimea 2,000 feet up on the high arid south central plateau and Semeis Observatory on the mountain slopes of the south coast. At the former we were shown the double astrographs, the large reflector (50-in.) for spectrographic work, the refractor with objective prism for radial-velocity determinations, a very short focus "stove pipe" telescope for work in the ultraviolet. We were taken to see the foundations being laid for a new telescope. Seven women were running the cement mixer and handling the wheel-barrows in the full blaze of the early afternoon sun. The temperature in the shade was 110°F.

Solar research was in progress in $H\alpha$ light with a vertical and in the K line with a horizontal set-up working in the 4th to the 8th order with resulting large dispersions. Radio astronomy is being developed vigorously at wave-lengths 1.5 m. and 10 cm. A special apparatus is in use for the study of atmospheric surges. A Mills Cross is planned for 21-cm. hydrogen research. In the courtyard of the main residence we sat down with our hosts to an abundant lunch with the wines of the country and luscious grapes and peaches.

At Semeis the following day we were seeing an institution founded in 1908 and known throughout the astronomical world for the work of its late director, Dr. Shajn, and for its great 41-in. refractor ordered originally by the Czar from the Grubb Parsons firm at Newcastle-on-Tyne. This lens was irreparably damaged when taken to Berlin by the German invaders in the second great war. Many of us had seen it lying chipped and scratched on the floor of a building at Pulkova Observatory. Dr. Shajn's office and portrait were shown to us and his great atlas of the diffuse nebulae. We examined the plates taken with their 60-cm. aperture meniscus telescope; their solar spectra and flare spectra. They took us to the brink of a hill where a plane mirror throws the light of nebulae down to a special spectrograph in the valley. We saw the aluminium-coated pyrex coelostat and the solar laboratory with its slits and grating. Observational conditions in the southern Crimea are excellent since the atmosphere is remarkably steady.

After much needed cool drinks and fruit we bade farewell to our

genial hosts and descended by steep winding roads to the sea where a short walk brought us to a rocky beach with huge waves rolling in, beyond the hazard of which swimming in the swells was a life-restoring delight.

Late that evening we embarked on S.S. "Ukraina", going ashore next day on the east coast of the Black Sea at Novorossi, then Tuapsi where we visited the fruit market and saw nearly everyone carrying home melons, then Sochi a health resort town of lovely parks and fountains overlooking bathing beaches. The following morning at 5 a.m. we disembarked at Sukhumi, a thriving seaside resort backed by the foot-hills of the high Caucasus. Part of a large park is a monkey reserve attached to the Biological Centre of the Academy of Medical Sciences. A slow train journey through the great valleys between the northern rampart of the Caucasus and the less high southern range brought us through the town of Gori on the Kura River with a huge statue of its famous son Stalin on the station platform; and so to the capital of the Georgia S.S.R., Tbilisi (Tiflis). This is a city of 800,000, with many fine streets and public buildings on either side of the winding Kura River which flows south eastward 300 miles to the Caspian Sea. It is an historic city and with apparent pride the interpreter informed us that Christianity was brought up into south-east Europe through Tbilisi in the 4th century. We were shown extremely interesting 12th-century churches on 4th-century foundations, one now a museum, one still in use for Georgian Orthodox worship, and one in the care of a few pathetically poor nuns.

From Tbilisi we drove up the valley and high up mountain roads through pines, spruce and balsam to Abastumani Observatory, at altitude 5,300 feet in the southern Caucasus. Sixty years ago S. P. Glasenap had selected this site because of the remarkable transparency of the atmosphere but his dream of a great research observatory was not realized under the Czarist regime. Today this first of the Soviet mountain observatories is a hive of activity. We saw the 40-cm. Zeiss refractor with two 20-cm. cameras on the same mounting frequently used for objective prism work. A lunar electropolarimeter is sometimes used at the main focus of the large telescope. There are domes for a 30-cm. refractor; a 33-cm. reflector with fork type mounting for photoelectric work; a 44-cm. Schmidt used largely for Cepheid variables and for colour indices of extragalactic nebulae. Solar research includes work in $H\alpha$, the infrared, prominences and flares. A fourth building in this series is for problems of night glow in the visible, ultraviolet and infrared regions. The latest addition is a new Maksutov 70-cm. meniscus telescope with an 8° objective prism (the second largest known) giving stellar spectra down to 3,500 A. of 13th magnitude stars with 40-minute exposure.

Library, laboratories, staff house and a dining room are built under the

pines. We were entertained at dinner from 3:30 p.m. to 5 p.m., then each given a bag of the finest Georgian fruit and a bottle of red Georgian wine for our long drive back to Tbilisi and a night train to Armenia.

In the darkness we came through the mountain passes and by daylight ran south very close by the carefully guarded Turkish frontier to the capital of this Socialist Soviet Republic, Erevan. It is situated on a high hot plateau. About fifty miles to the south on the Turkish side of the frontier rises a magnificent massive with Mt. Ararat's snow capped peak standing nearly 17,000 feet above sea level. From this prosperous little city of 400,000 (eleven times its population in 1917) we drove up 4,000 feet into the mountains to the Burakan Astrophysical Observatory, established in 1946 by the Armenian Academy of Sciences of the U.S.S.R. The Director is the distinguished Armenian scientist Dr. V. A. Ambartsumian. He and his staff conducted us around this impressive group of buildings where seven or eight telescopes are in operation, astrographs for two-colour plates of variable stars, a Schmidt instrument for research on stellar associations (a relatively new idea which had its birth at Burakan in 1947), a 21-in. Schmidt for colorimetric work on galaxies, a spectrograph for nebula studies and a 3-m. parabolic mirror for solar radiation of 50-cm. wave-length. As the sun was flooding the western slopes of Ararat with slanting golden light we went up to the site of the radio telescopes, three large flat aerials for study of discrete sources at wavelengths of 1.5 m. and 4.2 m. Other radio telescopes are under construction at a still higher altitude where a 1-m. Schmidt is also being erected.

Theoretical, statistical and observational work are in full flow at Burakan. One comment may be of interest about the equipment in the computation room—side by side with the computing machines is the abacus. The speed with which calculations are done on this simple apparatus is amazing. From Leningrad to Erevan we saw it in use in observatories, post offices, banks, shops and even in the markets.

That evening in the new Intourist Hotel in Erevan, the Director and his colleagues entertained us with true Armenian hospitality, informality and friendliness at a dinner at which innumerable toasts were proposed. We sat down at 9:30 p.m. and rose at midnight, said farewell to our hosts, packed our bags, slept for four hours and then were off to the airport. Mt. Ararat's snowy summit was touched softly by the "roseate fingers of dawn" as we winged our way northward on August 31. We passed over the lesser Caucasus, the great valley of the Kura, and the high Caucasus getting a splendid view of Mt. Elbrus towering snow clad to more than 18,000 feet; over the southern steppe land to Rostov airport on the delta of the Don and the Donets then off again over the vast collective farms of Ukraine and so by mid-afternoon to Moscow.

AN EARLY 19TH-CENTURY STAR MAP AFTER ARATUS

By Arthur E. Covington
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When groups of stars in the sky are being pointed out and called by names which bear little resemblance to the glistening patterns of light, many a person has felt thankful for the small child who does not hesitate to ask, "Why do people think there are kings, birds, and giants in the sky, and just where are they?" Perhaps the simplest answer is to suggest that the early people, from whom we inherited these names, had one thing in common with the small child—both were consciously viewing for the first time the splendour of the heavens and feeling a deep sense of mystery. Without any previous knowledge of these objects, it was only natural for these early people to talk about, and to discuss the stars in terms of the only symbols they knew; the familar shapes of man, beast, and other objects of their world. After all, this procedure is not far removed from the play of a small child in which so many things are imagined; or for that matter, it is not far removed from the current practice of using old words to describe recent discoveries. It is remarkable that these people of long ago felt the inner urge to view the stars, invent names, and above all, to hand to us a tradition.

Thus the study of the history of astronomy leads to a search for records of the past, and one soon finds that there are many remarkable fragments from the ancient Mediterranean world which are of astronomical significance. One of these is the poem, "Phaenomena", written by the Greek poet Aratus, who lived about 270 B.C. This work was, perhaps more than anything else, responsible for fixing and perpetuating the celestial positions of the mythical images of the past. The poet was also a physician, contemporary of Euclid, and spent much of his life at the court of Antigonous Gonatas of Macedon, where his poem was written. The astronomical concepts in the poem were taken from the work of Eudoxus. The poem became exceedingly famous, was translated into Latin by Cicero, and at later times into other languages. The imagery of the poem certainly serves as a stimulus for the imagination to create pictures of the mythical figures interlocked with the stars, and undoubtedly in the past has guided the hand of many an artist called upon to construct a star atlas with illustrated constellations. Such an atlas of stars and figures certainly excites the curiosity of the viewer as well as serving as a visual aid for

gaining at a glance the basic astronomical and mythical content of the poem. One map of the heavens made according to the "Phaenomena" appears in the Greek edition of the poem by F. C. Matthiae (1816), published in Frankfurt, and has been reproduced here as figure 1 for the northern hemisphere, and figure 2 for the southern hemisphere.

In this short note it may not be amiss to quote the Prologue from the recent English translation (Barnholth, 1958), which is concerned only with those parts of astronomical interest. These introductory lines are famous and well remembered for the reason that the sixth line is quoted by St. Paul, in Acts 17:28. These were addressed to the Athenians on Mars Hill. The prologue reads:

> From Zeus above let us begin,
> We ne'er forget his name;
> Man's roads and marts are full of Zeus,
> The harbors and the seas;
> We all have constant need of him,
> For we his offspring are.
> He kindly manifests to men
> The signs to give them aid;
> And mindful of their daily needs,
> Arouses them to work.
> He tells them when the land is right
> To cultivate and plow;
> The proper time to set the plants,
> And when to sow the seeds.
> For He it is who fixed above
> The yearly signs and stars,
> To indicate the seasons right,
> That crops might give their yield.
> So, first and last, men rev'rence him,
> For He is great and good.

In the planisphere reconstructed from the poem of Aratus, it is interesting to see that the intersection of the zodiac with the celestial equator lies in the constellation Aries, while in modern planispheres, this important reference point lies in Pisces. This noticeable change has been brought about by the precession of the earth's axis of rotation during the 2,000 years since the observations described in the poem were made. One complete rotation requires 25,800 years. Another point of dissimilarity to modern maps is the absence of the figures about the southern pole. This may be taken to indicate that the inventors of the celestial figures lived in the northern hemisphere and consequently could not see this part of the sky.

Although there are many modern atlases for the purpose of locating

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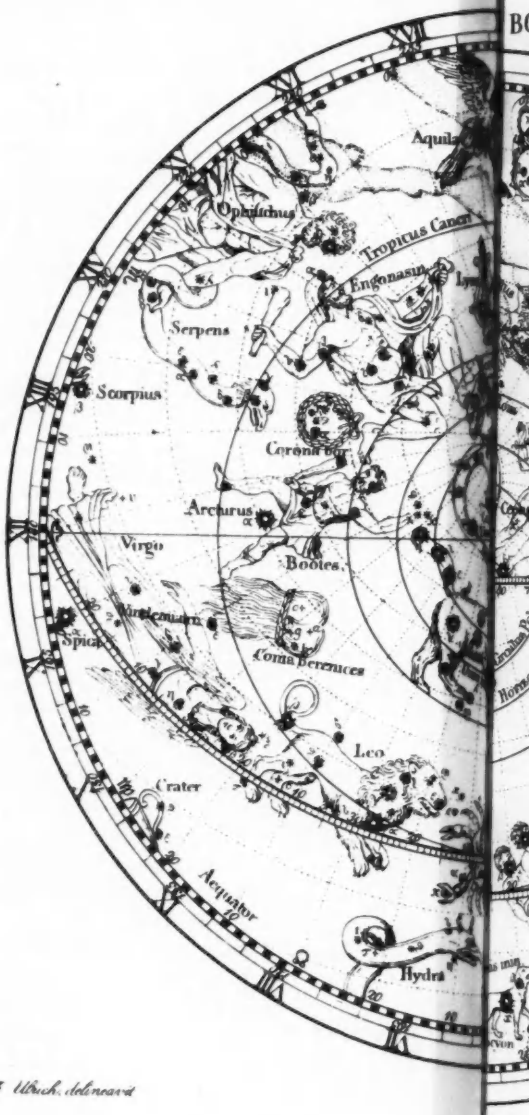
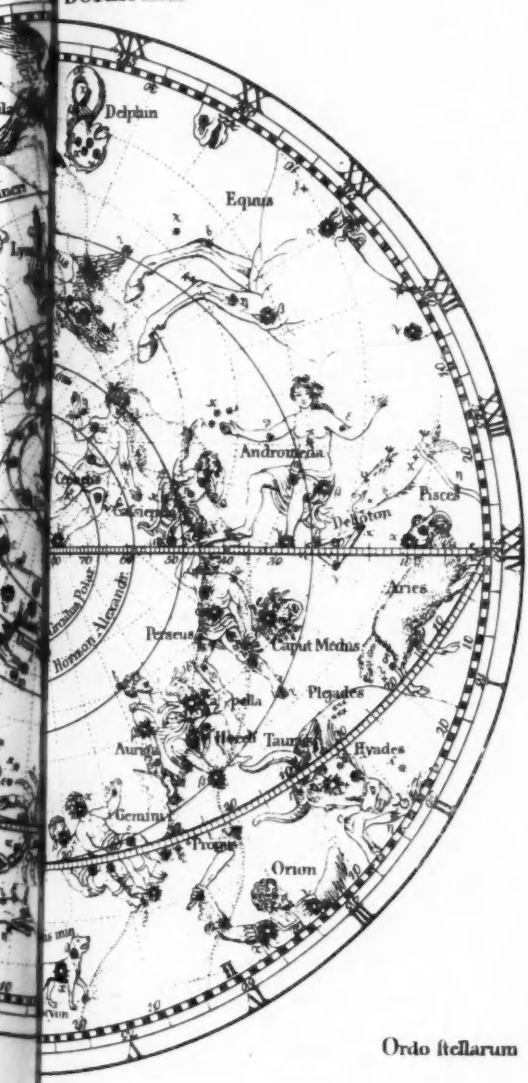


C. F. Ulrich. delineavit



Ordo ſtellarum

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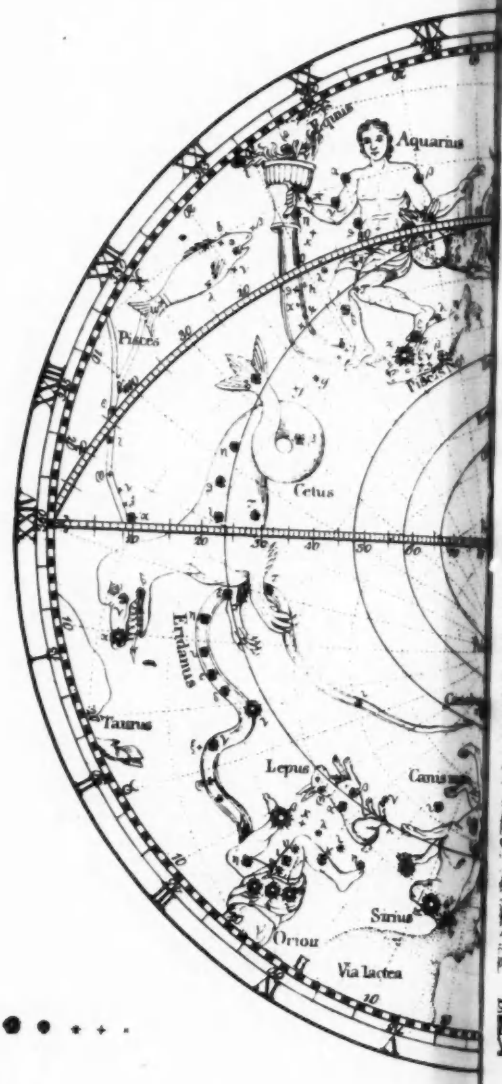
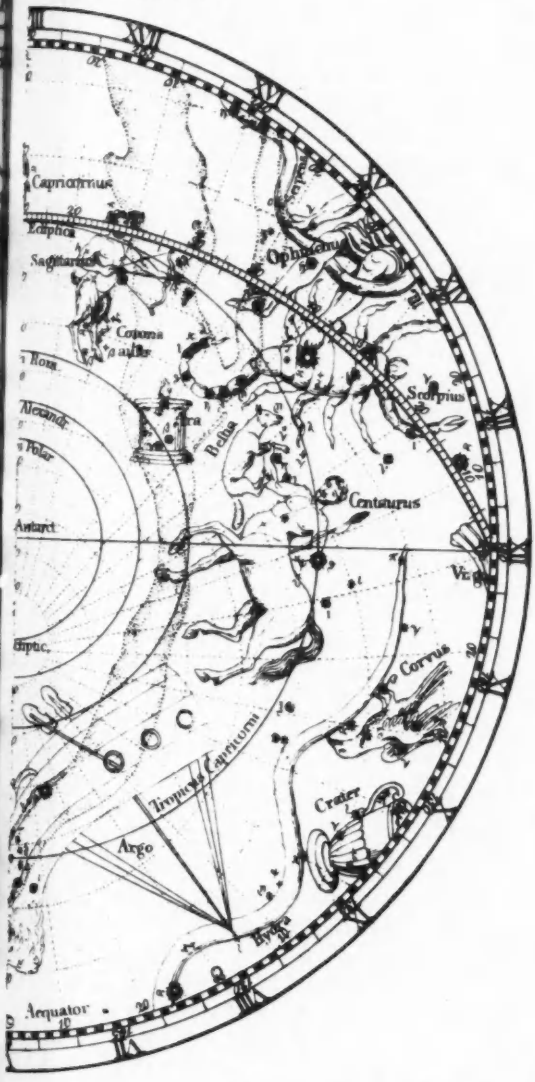

Aquarius
Pisces
Cetus
Eridanus
Taurus
Lepus
Canis
Sirius
Orion
Via lactea

UM AUSTRALE



Steindruck von Joh. Leonhard in Frankfurt Main

stars in the sky, it is hoped that the early 19th-century map shown here will be interesting in itself, and will stimulate interest in the history of astronomy. For some, the pictured mythical forms may provide visual images to assist in remembering the various groups of stars. Mention should also be made of other astronomical treasures of the past. One of these is a 2nd Century A.D. planisphere of the heavens appearing in a Roman manuscript now in the British Museum Library. Another, the most interesting of all, is a white marble globe, 65 centimetres in diameter, supported by the god Atlas. This globe with the celestial figures in relief is now in the National Museum at Naples, and dates from the 1st Century B.C. Photographs of the early planisphere and globe are shown in the excellent book "Astronomical Atlases" (Brown, 1932). Perhaps it is not too much to imagine that Aratus, while writing his poem, had a similar celestial globe before him.

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CANADIAN SCIENTISTS REPORT-XV

MAGNETIC STORMS

By J. A. Jacobs
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The continuous magnetic records of any observatory show that the earth's magnetic field is not constant but is continually changing. There are two distinct types of change, however—transient fluctuations and long term secular changes. The secular change was discovered by H. Gellibrand in 1634 and, over a long period of time, the net effect may be considerable. For example the horizontal component of the earth's magnetic field at Cape Town has decreased by 21 per cent. in the hundred years following the first observations in 1843. Again the direction of a compass needle at London was 11½° east of true north in 1580 and 24¼° west of true north in 1819, a change of 35¾° in 239 years.

Potential theory enables a field, observed over a closed surface, to be separated into two parts due to currents and poles within and without the surface. Applied to the earth's magnetic field as observed on the surface, such an analysis shows that the cause of more than 95 per cent. of the main field and of the secular variation must lie within the earth. It is not the purpose of this article to discuss the problem of the origin and maintenance of the earth's main magnetic field and the secular variation. These are among the oldest and most fundamental problems of geophysics, and it is only very recently that any real progress has been made. The most probable answer is the dynamo theory, which suggests that the field is ultimately produced and maintained by a mechanism of induction, the magnetic energy being drawn from the kinetic energy of fluid motions in the liquid core of the earth.

Transient variations arise from causes outside the earth and comprise but a fraction of the total field. They produce no large or enduring changes in the earth's field but the changes may be quite rapid. During a magnetic storm for example the compass may swing half a degree in a few minutes, and every day it moves through about 10 minutes of arc in a more or less regular "daily variation".

Transient magnetic variations were first noticed by G. Graham in 1722. Observations of the magnetic field were later begun at several places in

Europe, leading to the first discovery of a magnetic storm. In 1741 A. Celsius and O. P. Hiorter announced that violent changes in the geomagnetic field occurred during a magnificent display of northern lights (aurora) at Upsala, and G. Graham confirmed this connection between the two phenomena by simultaneous observations in London. During the early 19th century many magnetic observatories were built, greatly increasing our knowledge of geomagnetism. After the sun-spot cycle was discovered by S. H. Schwabe in 1843, the relationship between sun-spot variation and magnetic disturbances was found by E. Sabine in 1851 using data obtained from the magnetic observatory at Toronto.

Realizing the need for more polar magnetic data, K. Birkeland organized Arctic expeditions, and the results obtained from these expeditions and from the First Polar Year (1882–1883) were published in three important memoirs in 1901, 1908, and 1913. He also showed in the laboratory that when a stream of charged particles is projected towards a magnetized sphere, they are deflected towards the poles by the magnetic field. The mathematical theory of the motion of a stream of charged particles ejected from the sun and entering the earth's magnetic field was later developed by C. Störmer, and in more recent years W. H. Bennett has perfected the early experimental work of K. Birkeland, building what he has called a Störmertron.

The first systematic study of magnetic storms was made by N. A. F. Moos in 1910. An extensive world wide morphology of magnetic storms was started by S. Chapman about ten years later and his results and discussions have appeared in a series of papers published in 1918, 1927 and 1935. His work has been carried on by E. H. Vestine and by a large and growing school of Japanese workers in this field, in particular by T. Nagata and N. Fukushima.

Most days show some magnetic disturbance, but except in periods of very violent activity, it is found that the disturbance *D* is superposed on a regular daily variation *S*. *S* is seen in its pure form on a quiet day when it is denoted by *Sq*. It is found that each magnetic element is affected in a characteristic way by the variations *S* and *D*. The type and range of variation vary considerably with geographical location, with the time of year and the range and incidence of *D* also vary from year to year. *D* is usually separated into two parts *DS* and *Dst* where *DS* is the diurnally varying part of the storm or the disturbance daily variation and depends on solar local time and *Dst* is the storm time variation, reckoned from the commencement of the storm.

It is found that the intensity of magnetic disturbances increases from low to high latitudes up to about magnetic latitude 65°, the latitude of

the auroral zones, i.e. the zones where aurora are most frequent. Within these zones, the intensity, although considerable, decreases slightly towards the magnetic poles. Although disturbances of low intensity may be confined to a small area of the earth's surface, large disturbances (magnetic storms) are world-wide phenomena. Intense magnetic storms usually commence suddenly at almost the same instant (of the order of ½ minute) all over the earth.

The fundamental studies of S. Chapman and E. H. Vestine have revealed many systematic features of magnetic storms, although it is impossible in a short review to describe them in any detail. The *Dst* part of a typical magnetic storm begins with an abrupt change at sudden commencement and after a few hours the intensity of the horizontal component begins to decrease markedly in middle and low latitudes (the main phase of the storm). In high latitudes the variations are more rapid and violent. A gradual decrease of activity then follows, the field recovering to a normal state after several days.

Many theories of magnetic storms and aurora have been proposed to explain the observed characteristics. As V. C. A. Ferraro has remarked "the history of magnetic storms and aurora is strewn with the wrecks of discarded theories". The work of S. Chapman and V. C. A. Ferraro has dominated thinking during the last few decades. In their theory a neutral stream of ionized particles is ejected from the sun—the sudden commencement of a magnetic storm being interpreted as the compression of the geomagnetic field due to the approach of the corpuscular stream towards the earth. As the stream advances the flow of charged particles under the influence of the earth's magnetic field forms a curved hollow in the vicinity of the earth. The development of the *Dst* field in the main phase of magnetic storms is thus explained by the formation of an equatorial electric ring-current. The Chapman-Ferraro theory has been extended by D. F. Martyn and alternative theories proposed by H. Alfvén and S. F. Singer. Although these theories can explain many features of magnetic storms and related phenomena, no theory has as yet reached the stage of quantitative explanation even for the main features of magnetic storms.

Ever since R. C. Carrington observed the first recorded solar flare at Greenwich in 1859, evidence has been steadily accumulating that magnetic storms, outstanding auroral displays, radio fadeouts and increased atmospherics are all attributable to violent flares in the sun's atmosphere in the immediate neighbourhood of sun-spots. All these phenomena follow the well established 11-year cycle of sun-spot activity, the year 1957–58 being the last maximum. The International Geophysical Year was thus

planned to take place under optimum conditions. Of considerable interest is the fact that sun-spot numbers during 1957–58 attained an apparently unprecedented level. It takes about 27 hours for ionized particles to travel the 150 million kms. from the sun to the earth. Ultra-violet solar flares, however, are transmitted through space with the speed of light and are thus observed on earth only 8 minutes after they occurred on the solar surface. We thus have some chance to predict magnetic disturbances on the earth, since solar flares and the ejection of ionized particles are closely related with each other. However we do not know the precise mechanism of the proton and electron emissions from the sun nor do we completely understand the process in the upper atmosphere which ionizes the air.

The air above the earth's surface is virtually non-magnetic and non-conducting up to a height of about 70 km. above which there are two main ionized layers, the E-layer at about 100 km. and the F-layer at about 200 to 300 km. From an analysis of the earth's transient magnetic fluctuations it is possible to calculate the strength and direction of an electric current system flowing in the ionosphere which could produce the observed magnetic field.

In 1882 Balfour Stewart suggested that these electric currents are due to electromotive forces induced by daily periodic motion of the air in the presence of the earth's main magnetic field. This theory, known as the dynamo theory, was first investigated in detail for quiet day variations by A. Schuster in 1908 and later by S. Chapman in 1914 and 1919, although it was not until 1924 that E. V. Appleton demonstrated the existence of the highly conducting E-layer.

Similar electric current systems have been deduced by S. Chapman which could account for the disturbances which take place during a magnetic storm. World-wide analysis shows that the main features of magnetic disturbances are such as would be caused by three great electric currents, measured in hundreds of thousands of amperes, flowing in the upper atmosphere. These three currents are in the zones of maximum auroral frequency in the north and south polar regions and around the earth above the magnetic equator. The latter current appears to have a belt of greatly increased intensity concentrated in a narrow width of about 200 km. The demonstration of the existence of these currents, their nature and their cause, is an outstanding problem in geomagnetism, and one which, it is hoped, will be solved during the International Geophysical Year.

A dynamo theory to interpret the magnetic field at the time of sudden commencement *SC* of a magnetic storm has been developed by T.

Obayashi and J. A. Jacobs, on the assumption that the main source of electromotive force generation is due to an increase in the electrical conductivity in the polar regions. The change at a *SC* is so abrupt (within a few minutes) that it is reasonable to assume that the wind system in the ionosphere will not change. The ionosphere is no calm aerial sea but is torn by great horizontal winds and currents, and a proper understanding of these turbulent conditions would do much towards a better understanding of the physics of the ionosphere.

Using the wind system estimated from the quiet day field, T. Obayashi and J. A. Jacobs have computed the electric current system at the time of commencement of a magnetic storm, assuming an appropriate change in the electrical conductivity as the disturbance from the sun reaches the earth. Good agreement with observed results has been obtained and it suggests that a dynamo action in the upper atmosphere may be the dominant cause of geomagnetic variations during disturbances. Moreover, a consistent wind system was found which can produce the observed geomagnetic variations both for quiet and disturbed conditions with a reasonable range of conductivity changes in the polar regions; and the velocity of the winds is exactly the right order of magnitude as obtained by radio observations of the ionosphere.

Proof is still needed, however, that electric currents actually do flow in the upper atmosphere and that they are more than just a mathematical model with which to explain the observed magnetic variations. This proof we hope will be forthcoming during the International Geophysical Year. With a single observatory only a limited amount of information may be learned about an overhead electric current system, whereas much information may be obtained from a network of stations.

In the United States, an east-west network of five stations, with the main location at Climax, Colorado, and a short north-south arm with two additional stations have been set up to study the overhead currents in detail, and to provide information on any possible connection between meteorological and geomagnetic effects, possibly involving ionized air circulating in wind systems in the lower ionosphere.

A five-station fine-spaced network, centred at Huancayo, Peru, very near the magnetic equator has been established to study the equatorial current. Stations in South America and in the Pacific have been set up for the same purpose. Initial data from Koror in the west Pacific reveals both the existence of this current and its rather limited horizontal extent.

Besides measurements at land observatories, rockets and possibly satellites will carry magnetometers up into the regions where the currents are suspected to exist. They can thus obtain data about the earth's

magnetic field in space sampling a wide range of altitudes. These experiments may give the ultimate answer as to the existence of the currents and their location.

Four satisfactory sets of data on magnetic intensity have been obtained in the Line Island area in the central Pacific at altitudes up to 135 km. These measurements were obtained by the United States icebreaker U.S.S. "Glacier" during October 1957 using a nuclear free-precession magnetometer, fired from a Rockoon, i.e. a balloon launched rocket. These flights were made on an approximate north-south line crossing the latitudes of the equatorial electrojet. The data indicate an irregular, larger than normal decrease in the total magnetic intensity within the altitude range 97–121 km. at 0° latitude indicating the presence of an electrical current system. Detailed analysis of one flight indicates a horizontal current sheet extending vertically from 97 km. to 110 km. From 110 km. to 117 km. there is little or no current flowing; at 117 km. there is another horizontal current sheet extending vertically at least to the peak altitude of 121 km. The other flights also indicate a two-layer current system. The full reduction of all the flight data when combined with the ground station measurements are expected to yield further information on the equatorial electrojet.

At the close of the International Geophysical Year it is hoped that a vast amount of data will have been obtained on the physics of the upper atmosphere and that these preliminary confirmations of our ideas and theories will be further strengthened.

VARIABLE STAR NOTES

By Margaret W. Mayall
The American Association of Variable Star Observers

Most of the so-called regular long-period variables are not as regular as their mean light curves seem to imply. For this reason, many more observations are needed. The following miscellaneous notes on some of the more erratic of the long periods, plus notes on many semi-regular and irregular variables, are compiled from the more than 50,000 observations received from A.A.V.S.O. observers during 1958. The U Geminorum-type variables will be reported on in a later issue of these notes.

000339 *V Scl.* A 9th mag. maximum near the end of November follows a faint (10½) one in the middle of February.

001620 *T Cet.* More observations are needed of this bright semi-regular variable. A 5.7 mag. maximum was observed the first of September. The period of about 160 days has held for several years.

003840 *RX And.* A Z Camelopardalis-type variable which was quite regular in its periodicity of about 14 days, but with amplitude varying from one to three magnitudes.

011041 *UZ And.* The faint maximum of 1957 was followed by a 9½ mag. one early July.

011272 *S Cas.* The sequence has been checked photoelectrically, and is said to be very good.

013238 *RU And.* The amplitude seems to be decreasing again. It was about three magnitudes before 1940, about one magnitude from 1940–1952, then increased until it was three magnitudes 1955–1957.

021024 *R Ari.* The faint maximum of 1957 was followed by two bright (8th magnitude) ones observed during the last of March and the last of September.

021143 *W And.* The maxima continue to alternate bright and faint. A bright 7½ mag. one was observed the middle of August.

021403 *o Cet.* The 1957 broad, faint maximum and the 1958 bright one have been described in these notes. (See this JOURNAL, vol. 52, nos. 5 and 6.) The interval between them was equal to the mean period–332 days.

050611 *RX Lep* = *Zinner* 357. Not much variation seen during 1958.

050953 *R Aur.* Normal maximum was observed in the middle of April. A marked still-stand for nearly 100 days on rising branch of curve.

053005 *Orion nebula region.* More than 50 variables within one square degree of the Trapezium are within reach of visual observers with telescopes of about 8 inches or larger. It is a difficult but interesting region, with the stars involved in nebulosity. All the variables are of RW Aur-type, very erratic, sometimes almost constant in light, other times with rapid changes. Leif Robinson is preparing an identification chart. A few other observers should join him in a concentrated attack on the region.

053326 *RR Tau.* Another RW Aur-type variable for which observations with large telescopes are needed. During the 1957–58 observing season it varied between 11

and 13 with some indication of a 30-day periodicity. During the fall of 1958, the observations ranged between 12 and 13½, with little or no indication of periodicity.

054319 *SU Tau.* This R CrB-type variable has been at maximum for over two years.

054705 *CN Ori.* A faint Z Cam-type variable for which more observations are needed.

055122 *BQ Ori.* An interesting bright semi-regular variable which varied between 7½ and 8½ during the year.

063462 *RR Pic.* Nova Pictoris 1925 remains about constant at 11.5 mag.

065208 *X Mon.* For many years this star was quite regular with a period of 155 days, and an amplitude of about two magnitudes, but since 1956 it has been very irregular with a range of less than one magnitude.

070109 *V CMi.* A bright 8th mag. maximum in November 1957 was followed by a very faint 11th mag. one in November 1958.

071069 *RU Cam.* An interesting bright Cepheid with a period of 22 days, observed by Norman Hutchings. More observers are needed.

080835 *CP Pup.* Nova Puppis 1942 continues to remain constant at 11.2 mag.

081473 *Z Cam.* Varied throughout the year with an amplitude of from 1½ to 3 mag.

082405 *RT Hya.* Another variable, which for many years was quite regular, with a period of 251 days, and has now become unpredictable. More observations are needed. The magnitude range is about 7½ to 9.

093178 *Y Dra.* Alternating bright and faint maxima. A bright one, 8½ mag., was observed in the middle of May.

094836 *U LMi.* Less than one magnitude variation, instead of the former two magnitudes. More observations are needed.

095814 *RY Leo.* Less than a magnitude range instead of the 2½ in former years.

101420 *AD Leo.* Several observers have been watching this flare star (UV Ceti-type) for about 5 years, but no flare has been observed.

103769 *R UMa.* Two normal, 7½ mag. maxima were observed in 1958, following the faint one in 1957.

104159 *η Car.* Fairly constant, around 7th mag., for several years.

104620 *V Hya.* This red variable has two overlapping periods of about 532 and 6500 days, respectively. For the longer period, the range of magnitude is from about 6.5 to 12. For the shorter period, the range is two magnitudes or less. Twelfth magnitude minima were observed in 1908, 1925, and 1943. In December 1958, the variable was down to 11th mag., which indicates that another deep minimum is coming soon.

120012 *SU Vir.* A bright, 9th mag. maximum was observed the last of April.

123160 *T UMa.* A faint maximum (8.4) observed the first of December 1957, was followed by one a magnitude brighter in the middle of August.

134677 *T Aps.* An 8½ mag. maximum the last of October 1957 was followed by a very faint, 10th mag. one the middle of July.

145971 *S Aps.* After the one magnitude drop of this R CrB-type variable in the summer of 1957, it returned to normal brightness, then started to fade again. It reached about 13th magnitude in early March, then brightened slowly, until it was near its normal 10th mag. in November.

154428 *R CrB.* Constant, since June 1956.

155526 *T CrB.* Recurrent Nova Coronae Borealis 1866, 1946, has remained near 10th magnitude since 1947.

162815 *T Oph.* A very faint 11th mag. maximum the first of July, followed the bright (8½) one a year before.

172486 *S Oct.* A 10½ mag. maximum (two magnitudes fainter than normal) was observed in the middle of May.

174162 *W Pav.* A normal 9th mag. maximum the last of August followed the very bright maximum the previous November.

174406 *RS Oph.* Recurrent Nova Ophiuchi 1898, 1933 and 1958. The third observed maximum occurred July 14, magnitude 5.0.

174551 *U Ara.* A faint maximum, 9½ mag. was observed the last of August.

180445 *DQ Her.* Nova Her 1934 varies erratically between 13½ and 14¼ mag.

184134 *RY Lyr.* A 9½ mag. maximum in early November follows one a magnitude fainter in the middle of the previous December.

184205 *R Sct.* Varied between mag. 5 and 6 during 1958, with the exception of a short drop to about 6.3 in early June.

185512 *ST Aqr.* An 8th mag. maximum in the middle of November followed a 9th mag. one in October 1957.

185851 *BL Tel.* A drop of half a magnitude was observed the last of February, in this long period (778 days) eclipsing variable.

191033 *RY Sgr.* An R CrB-type variable, varied between 6 and 7.5 throughout the year.

193449 *R Cyg.* A 7th mag. maximum in late September followed the very faint (9th mag.) one in August 1957.

193972 *T Pav.* Two maxima observed in 1958: one in late February (7.4 mag.) and the other the last of October (9.0 mag.).

195553 *V476 Cyg.* Nova Cyg 1920 observed at mag. 16.2 by Claude Carpenter.

195656 *RR Tel.* Varies between mag. 9.1 and 9.4.

201520 *V Sge.* Observed to vary between 9½ and 13th mag., with some indication of several periods superposed. In addition, there are rapid, flare-type changes.

203501 *AE* Aqr. Many rapid flares of about 0.7 mag. observed.

221255 *CP Lac.* Nova Lac 1936 varied between mag. 14 and 15.

222457 *DO Cep.* UV Ceti-type, observed by Gunnar Darsenius. No flares.

222867 *R Ind.* A faint maximum, 10th mag., in the middle of June, followed an 8½ mag. one in November 1957.

224552 *DK Lac.* Nova Lac 1950, about 14th mag.

225542 *SZ And.* A very faint broad maximum, about 12th mag., was observed in June.

225859 *UV Cas.* An R CrB-type variable, constant at 11th mag.

235659 *WZ Cas.* Listed in the General Catalogue as a semi-regular variable, period 193 days. Observations over the last 5 years indicate a double period of about 400 days, with alternating deep and shallow minima.

A.A.V.S.O. Nova Search Report (From George Diedrich, Chairman): Observations of Nova Search Areas were made by the following 14 observers for a total of 376 area-nights. Each name is followed by the number of observations made in October and then November 1958: Robert Adams–2, 2; Richard Bates–8, 0; Frank J. DeKinder–9, 11; DeLorne Diedrich–7, 8; George Diedrich–19, 12; Elspeth Fraser–5, 0; Kenneth Fuller–65, 45; Geoffrey Gaherty, Jr.–8, 8; William L. Isherwood, Jr.–15, 9; John Morrison–3, 0; Robert Venor–4, 0; George Wedge–0, 8; James F. Wesling–2, 16; Katherine Zorgo–10, 0.

The Nova Search Division regrets the accidental death of one of its good observers, Mr. G. Harper Hall of Montreal, Canada.

Previously unreported are these observations by Miss Jane Shelby—7 area-nights in February, and 3 in May 1958.

The I.G.Y. may be over but the Nova Search is NOT. Help us catch the next one while it is still quite faint. Drop us a card and we'll send you details. Official observer or not, remember our slogan—"Keep Looking".

Observations received during November and December 1958: A total of 8,544 observations was received: 4,521 from 63 observers in November, and 4,023 from 59 observers in December.

Observer	Nov. Var.	Nov. Ests.	Dec. Var.	Dec. Ests.
Adams, R. M.	111	238	100	207
Ahnert, P.	...	...	13	47
Allin, R.	30	95	28	74
Anderson, C. E.	256	437	175	325
Anderson, E.	6	11	5	11
Anderson, R. E.	...	...	3	3
Bales, R. M.	6	10	3	7
Ball, A. R.	14	18	3	3
Beidler, H. B.	18	18	6	6
*Berg, R.	6	8	....	...
Bogen, L.		2	...	...
Braune, W.	...	...	9	68
Brechlin, D.	1	1	...	...
Breckinridge, J.	6	6	...	...
Byrd, W.	9	9	8	10
Carpenter, C. B.	...	...	6	6
Claus, D.	5	7	...	...
Conklin, J. H.	1	1	...	...
Cragg, T. A.	200	203	80	96
Darsenius, G.	11	25	5	5
de Kock, R. P.	136	572	127	675
Diedrich, DeL.	3	4	...	...
Diedrich, G.	8	19	...	...
Ellerbe, J. E.	...	...	3	5
‡Engelkemeir, D.	10	35	12	43
Erpenstein, O. M.	10	20	3	3
Faust, T.	1	1	...	...
Fernald, C. F.	262	671	245	444
Fletcher, D. M.	7	11	5	10
Ford, C. B.	211	222	141	148
Fuller, K.	50	57	49	49
Garland, G.	2	2	...	...
Godfrey, N. B.	20	20	38	39
Goodsell, J. G.	...	...	1	1
Greenley, R. M.	10	12	14	14
Grossenbacher, R.	3	3	...	...
Halvorson, D. O.	...	...	7	7
Hartmann, F.	149	165	165	182
Hess, M.	4	9	...	...
Hunter, T.	2	2	...	...
Hutchings, N. O.	5	5	...	...
Kelly, F. J.	10	16	...	...
Kindt, O. H.	4	5	...	...
Koons, L. D.	24	31	7	7
Lacchini, G. B.	57	105	10	10
Lattey, M.	6	19	6	7
Lorusso, D.	...	...	3	5
‡‡Lowder, W. M.	24	28	23	23
Magruder, R. S.	...	...	7	7
McPherson, C. A.	59	70	10	10
Miller, W. A.	2	2	3	4
Montague, A. C.	51	81	31	37
Morgan, F. P.	17	27	22	52
Olsen, N.	...	...	1	2
Oravec, E. G.	204	422	209	474
Parker, P. O.	33	67	45	49
Pearcy, R. E.	5	5	5	5
Peltier, L. C.	27	157	21	48
Peters, P.	...	...	9	9
Price, F. J.	14	17	16	16
Quester, W.	...	...	8	19
Renner, C. J.	149	149	...	...
Richter, A.	2	2	...	...
Rizzo, P. V.	15	18	11	11
Robinson, L. J.	1	1	44	76
Rosebrugh, D. W.	14	91	17	107
Rosenfield, C. C.	3	3	1	1
Rudolph, R.	...	...	37	238
Segers, C. L.	16	23	19	28
Silveira, W. M.	1	1	2	2
Skaritka, P.	119	212	...	...
Smith, G. W.	...	...	6	6
Solomon, L.	9	18	6	13
Taboada, D.	...	...	116	120
Thomas, M. A.	...	...	13	98
Traynor, F.	2	7	2	4
Valdez, M.	12	20	14	38
Vanzant, H.	3	4	...	...
Wend, R. E.	1	1	6	9

*Plus 76^m AE Aqr ‡Plus 10 PEP RS Oph ‡‡Plus 19^m UV Cet

NOTES FROM OBSERVATORIES

Dominion Astrophysical Observatory, Victoria, B.C.

In October C. R. Lynds of Berkeley came to the Observatory as a postdoctoral fellow of the National Research Council. He intends to investigate spectroscopically a group of stars which he suspects from photoelectric observations of being β Cephei type objects.

E. G. Ebbighausen arrived in September, on sabbatical leave from the University of Oregon and supported by a grant from the National Science Foundation. During his year here he will investigate the orbits of spectroscopic binaries with special emphasis on Algol and λ Tauri, and he will collaborate with R. M. Petrie in a re-examination of the orbits of several other interesting systems.

A. Beer of Cambridge, England has accepted a seasonal appointment as Visiting Professor for the first three months of the new year. He plans to make use of the Observatory equipment to measure the Hλ absorption in B-type spectra that were obtained at the Radcliffe Observatory in South Africa.

R. M. Petrie was appointed a Vice-President of the International Astronomical Union at its August meetings.

D. H. Andrews attended the December meetings of the American Astronomical Association held in Florida, and en route he visited the David Dunlap Observatory, the Dominion Observatory and the National Research Council.

The 33-foot dome and the attached coudé room for the 48-inch reflector were essentially completed at the end of the year.

Visitors to the Observatory included C. S. Beals, R. B. Code and A. M. Bancroft from Ottawa, D. B. and Mrs. McLaughlin from Ann Arbor, and K. Gottlieb and W. Buscombe from the Mount Stromlo Observatory, Canberra.

REVIEW OF PUBLICATIONS

Notice concerning the Astrophysical Journal

We would like to draw to the attention of members of the Royal Astronomical Society of Canada the following announcement of reduced subscription rates to the *Astrophysical Journal.*

By action of the Council of the American Astronomical Society, *bona fide* resident members of the various national astronomical societies (e.g. Fellows of the Royal Astronomical Society resident in the United Kingdom and Members of the Royal Astronomical Society of Canada resident in Canada) will be allowed the opportunity of subscribing to the *Astrophysical Journal* and its *Supplement Series* at the rates currently available to members of the American Astronomical Society. Those who wish to take advantage of these reduced rates should write to the Managing Editor of the *Astrophysical Journal* stating that they are duly elected members of their respective national astronomical societies and that they wish to subscribe to the *Astrophysical Journal* and/or the *Supplement Series* at the reduced membership rates.

These publications are the foremost professional scientific journals in the field on this continent.

EDITORS